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Cosmic Flows is an international multi-element project with the goal to map motions of galaxies in the Local Universe. Kinematic information from observations in the radio HI line and photometry at optical or near-infrared bands are acquired to derive the large majority of distances that are obtained through the luminosity-linewidth or Tully-Fisher relation. This paper gathers additional observational radio data, frequently unpublished, retrieved from the archives of Green Bank, Parkes and Arecibo telescopes. Extracted HI profiles are consistently processed to produce linewidth measurements. Our current "All-Digital HI Catalog" contains a total of 20,343 HI spectra for 17,738 galaxies with 14,802 galaxies with accurate linewidth measurement useful for Tully-Fisher galaxy distances. This addition of 4,117 new measurements represents an augmentation of 34% compared to our last release.

1 INTRODUCTION

locity can improve the growth rate constraints by a factor two (and up to five) compared to density alone for surveys with galaxy number density of about 10^{-2} Mpc^3 .

An associated use of peculiar velocities is for measurements of the local bulk flow and its physical interpretation toward understanding the global motion inferred by the CMB dipole (Watkins et al. 2009; Hoffman et al. 2014).

Such measurements on large scales at $z=0$ can detect signatures of modified gravity or non-Gaussianity through a scale-dependent growth rate or galaxy bias.

The international project Cosmic Flows has accumulated data to derive accurate distances from both Tully-Fisher and Fundamental Plane techniques. Two catalogs of distances have already been produced (Tully et al. 2008, 2013). For Tully-Fisher purposes, our group has been acquiring linewidths derived from HI 21 cm line profiles resulting from observations with the Green Bank Telescope at the US National Radio Astronomy Observatory and with the 13 channel Multibeam Receiver on the Australian 64m Parkes Telescope (Courtois et al. 2009, 2011b). Our observations are complemented by archival material from seven telescopes (GBT, NRAO 140-foot and 300-foot, Arecibo, Parkes, Nancay, Effelsberg). With the addition of the material to be discussed, now $\sim 18,000$ profiles and their interpretation are publicly available at the Extragalactic

Table 1. HI surveys conducted between 2000 and 2010 with Parkes 64m telescope. Data was retrieved from archival disks and explored. When signal to noise was sufficient, we reduced the data. Column 1 gives the internal Parkes program number. Column 2 gives the survey title, investigator's name and date of observation.

P248	HIPASS/ZOA Staveley-Smith/Webster (2000)
P290	Redshift behind Milky Way - Saunders-Staveley-Smith (2000)
P307	Southern Galactic Plane Survey: Full Survey (Dickey)
P312	Narrow-band HI MB Survey of the Magellanic System (Haynes)
P335	High Velocity Resolution HI study of Nearby Galaxies (de Blok)
P347	HI around dwarf spheroidal galaxies (Carignan)
P352	Formation & Evolution in Groups - role of HI (Forbes)
P357	Northern extension to ZOA (Staveley-Smith)
P364	Seibel-Danziger TF of spirals containing SNIa (2005)
P370	The baryonic Tully-Fisher HIPASS sample (Gurovich)
P387	Completeness & reliability of HIPASS (Zwaan)
P389	Narrow band observations of HIPASS edge-on spirals (Meyer)
P432	HI content of early type galaxies (Garduno)
P467	GASS : Galactic all sky survey McClure-griffiths
P475	HI content of early-type dwarfs in nearby groups (Bouchard)
P561	Mapping Mass Local Universe (Hong, Masters) (2006-2007)

Distance Database¹ (EDD) (Tully et al. 2009) website in the 'All Digital HI' catalog.

A high priority of the project is to increase the size of the sample by both going to larger redshifts and closer to the zone of avoidance while also homogenizing the distribution of distance measurements across the sky. This paper gathers original datasets retrieved directly at the archives of Green Bank, Parkes and Arecibo telescopes to complement observational programs dedicated to the Cosmic Flows projects. Extracted HI profiles are all consistently processed by our linewidth pipeline, which is now also used by the ASKAP-WALLABY collaboration and with the Effelsberg SDSS-Northern Sky Survey.

The first section of this paper presents the different samples of selected galaxies extracted from the archives. Subsequent sections discuss the data reductions and compilation of linewidths.

2 DATA RETRIEVAL

2.1 Parkes 64m

A search for archival material since 2000 obtained with the Parkes-64m telescope led us to review observational programs listed in Table 1.

Programs P364 (PI: Seibel & Danziger; 69 spectra retrieved) and P561 (Hong et al. (2013)) (139 spectra retrieved) produced a total of 142 measurements of linewidths that are now reduced as in Courtois et al. (2011b) and included in our catalog. The new material from Parkes can be identified in table 2 by "archi12" (archive search 2012) in the Source of Information column.

2.2 GBT 110m

At GBT four observational programs were studied: GBT06A027, GBT06B021, GBT06C049, and GBT08B003 (see Masters et al. (2014)). These programs provide observations of 530 2MASS galaxy targets, from which 486 galaxies were cross-identified with

a galaxy with a PGC number de Vaucouleurs et al. (1991), and 417 had sufficient signal to give an acceptable linewidth measurement. For 44 targets the signal to noise is insufficient for a galaxy distance measurement. The new material from the GBT archive can be identified in table 2 by "archi12" (archive search 2012) in the Source of Information column.

2.3 Arecibo 300m

We are following-up on each data release from the extended extragalactic HI blind survey at Arecibo conducted by Martha Haynes and collaborators. From 15,855 AGC numbers in Haynes et al. (2011), 11,941 were cross-identified with a galaxy with a PGC number. Of these, 1,296 spectra were already analyzed by us following previous ALFALFA releases (1-2-3), leaving us with 9,274 new spectra to inspect, which we carried out ordered by decreasing signal to noise ratio. The lower 5,000 spectra were left without analysis since the signal to noise was too low for proper linewidth measurements. This study results in $\sim 3,500$ HI linewidth measurements of which 3,440 are associated with new galaxies to our catalog of HI measurements. The new material from the Arecibo can be identified in table 2 by "hgm2011" (Haynes, Giovanelli, Martin 2011) in the Source of Information column.

3 DATA REDUCTION

The new HI profiles were measured in the same consistent way using "Wmean50". An algorithm written by us in IDL, as described in Courtois et al. (2009, 2011b). A W_{m50} parameter corresponds to the HI profile width at 50% of the mean flux within the velocity range encompassing 90% of the total HI flux. This window captures the rotation motions and measures only signal above the noise. In addition, W_{m50} was demonstrated to provide robust linewidth measurements insensitive to profile shape such as single peak profiles or asymmetric double peak profiles.

Appropriate adjustments of W_{m50} to remove a slight relativistic broadening and a broadening because of finite spectral resolution are applied before publication of the results:

$$W_{m50}^c = \frac{W_{m50}}{1+z} - 2\Delta\nu\lambda \quad (1)$$

with galaxy heliocentric velocity cz , spectral resolution after smoothing $\Delta\nu$ and λ determined empirically. Broadening is statistically described with $\lambda = 0.25$.

Linewidths are adjusted to twice maximum rotation velocities V_{max} by a model based upon samples of global profiles and detailed rotation curves (Tully & Fouque (1985), Verheijen (2001)):

$$W_{R,\ell}^2 = W_{\ell}^2 + W_{t,\ell}^2 (1 - 2e^{-(W_{\ell}/W_{c,\ell})^2}) - 2W_{\ell}W_{t,\ell}(1 - e^{-(W_{\ell}/W_{c,\ell})^2}) \quad (2)$$

with the subscript ℓ standing for the specifics of the linewidth estimate, with corresponding turbulent broadening $W_{t,\ell}$, and a transition from boxcar to Gaussian intrinsic profiles characterized by $W_{c,\ell}$. With the current linewidth convention, $W_{c,m50} = 100 \text{ km s}^{-1}$ and $W_{t,m50} = 9 \text{ km s}^{-1}$ give the best fit. The result, $W_{R,m50} \equiv W_{mx}$, is corrected for inclination with a division by $\sin i$ where i is the inclination from face-on. It is defined by the expression $\cos i = [\frac{(b/a)^2 - q_0^2}{1 - q_0^2}]^{\frac{1}{2}}$ where b/a is the ratio of minor to major axis and $q_0 = 0.20$ is taken as the reference for a galaxy viewed edge-on

¹ <http://edd.ifa.hawaii.edu>

Holmberg (1958).

Arguments can be made for a more complex dependence of q_0 . Fortunately, the choice of q_0 has a negligible effect on distance measurements if one is consistent between measurements. For example, $q_0 = 0.13$ yields an inclination of 81° instead of 90° for $b/a = 0.20$ resulting in a $1/\sin i$ difference on the corrected linewidth of only 1.2%. As one progresses toward larger b/a , the difference in assigned inclination is reduced but the $1/\sin i$ correction is growing. The product $(b/a)/\sin i$ is a roughly constant shift of 1.2% in the corrected linewidth at all inclinations $i > 45^\circ$. Handling every galaxy profile in the same manner will remove any significant effect on the measured distances (Tully & Pierce 2000).

Width error estimates are based on the level of the signal, S , at 50% of mean flux over the noise, N , measured beyond the extremities of the signal. Only profiles with error estimates smaller than 20 km s^{-1} are retained for galaxy distance measurements. The corresponding flux per channel is $S/N \geq 2$. Examples of new profiles from Parkes, GBT and Arecibo can be seen in Fig. 1. All these 4,117 new HI material measurements are given in an online table with this article, with examples given in Table 2. In Table 2 the telescope acronym PAKS, GBT and ALFA stands respectively for Parkes, Green Bank and Arecibo telescopes.

4 DISCUSSION AND CONCLUSION

The Cosmic Flows project started in 2006 by compiling available digital HI spectra for Tully-Fisher measurements of galaxy distances. In Courtois et al. (2011b), the HI online catalog, built using "Wmean50" code, contained 16,004 galaxies from which 11,074 had a linewidth of acceptable quality. Some of these profiles were re-reduced, for example, when a new HI profile coming from a different telescope gave a discordant value or, by contrast, was confirming a dubious old measurement. Also some profiles were scrutinized by eye at the time of matching those radio measurements to *I*-Band, Spitzer or WISE photometry for the purpose of deriving a galaxy distance (Courtois et al. (2011a), Sorce et al. (2014), Neill et al. (2014)).

We thus provide with this article a fully updated catalog of 17,738 galaxies from which 14,802 have a high enough signal/noise for a distance measurement, an increase of a third over our previous data-release. Table 3 provides the first few lines of this updated catalog.

The importance of building large coherent datasets is also manifested in improvements in our comprehension of galaxy physics, for example with the new calibration of the baryonic Tully-Fisher relation (Zaritsky et al. 2014). In the near future, teams will be able to measure consistently with sufficient signal, linewidths of tens of thousands of galaxies by combining output from the multi-dish telescopes: southern ASKAP-Wallaby and northern HI Westerbork surveys WNSHS (Duffy et al. (2012)).

These Tully-Fisher measurements are complemented by Fundamental Plane distances for elliptical galaxies (Springob et al. (2014)). In the future, the TAIPAN survey (Kuehn et al. (2014)), starting 2015 at the UK Schmidt telescope in Australia, will measure 500,000 redshifts to $z \sim 0.2$ with $r \sim 17$, $K \sim 14$ and about 10,000 galaxy distances with typical errors of the order of 20%.

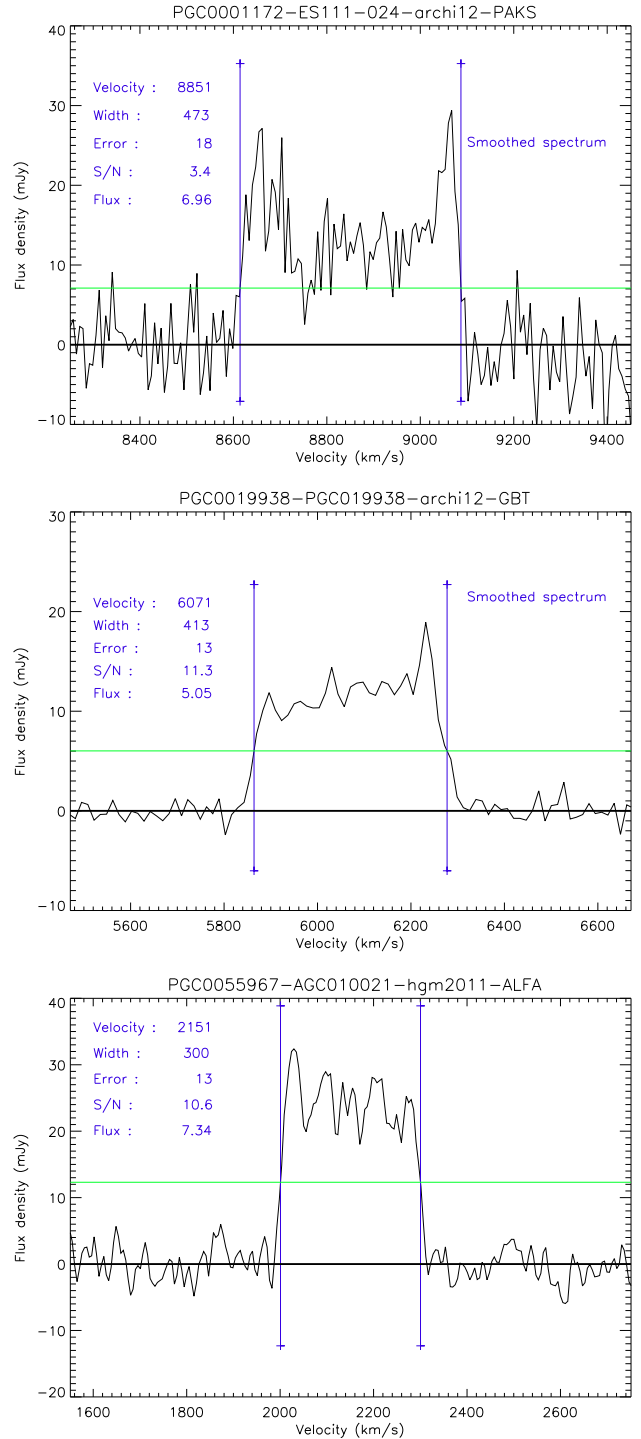


Figure 1. Examples of three new HI profiles from Parkes, GBT and Arecibo telescopes (top to bottom). All the 20,343 HI spectra analyzed for the 17,738 galaxies can be viewed online with the request including the PGC number of the galaxy at the end of the line as one of the galaxy in this example: for PGC0001172, type : "http://edd.ifa.hawaii.edu/get_profiles.php?pgc=1172"

Table 2. The full table is available as online supplementary material. It contains 4,117 galaxies with new additional line width measurements. Description of the columns: (1) PGC: Principal Galaxy Catalog name (2) Alternative galaxy name (3) Source code for HI spectrum (4) Telescope acronym (5) V_{hel} : heliocentric velocity (6) W_{m50} : line width at 50% of mean flux (7) W_{m50}^c : line width at 50% of mean flux corrected for redshift and spectral resolution broadening (8) W_{mx} : line width approximating twice the maximum rotation, not corrected for galaxy inclination; blank if error > 20 km/s (9) eW : error in linewidth measure in km/s (10) S/N : signal to noise (11) HI line flux in Jy km/s (12) Spectral channel resolution in km/s (13) F_{m50} : flux/channel at 50% of mean in mJy

PGC	Name	Source	Tel	V_{hel} km/s	W_{m50} km/s	W_{m50}^c km/s	W_{mx} km/s	eW km/s	S/N	Flux Jy.km/s	Res km/s	F_{m50} mJy
1172	ESO111-024	archi12	PAKS	8851	473	456	447	18	3.4	6.96	1.7	7.1
19938	PGC019938	archi12	GBT	6071	413	398	389	13	11.3	5.05	3.3	6.0
55967	AGC010021	hgm2011	ALFA	2151	300	295	286	13	10.6	7.34	5.2	12.3
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Table 3. The full table is available as online supplementary material. It contains the averaged measurements for 14,802 galaxies with high quality spectrum. Description of the columns: (1) PGC: Principal Galaxy Catalog name (2) Alternative galaxy name (3) V_{hel} : averaged heliocentric velocity (4) W_{mx} : weighted averaged line width approximating twice the maximum rotation, not corrected for galaxy inclination (5) eW : error in linewidth measure after averaging in km/s (6) N : number of averaged independent measurements (7) S/N : signal to noise (10) HI line flux in Jy km/s

PGC	Other name	V_{hel} km/s	W_{mx} km/s	eW km/s	N	S/N	Flux Jy km/s
4	AGC331060	4458	154	16	1	8.5	1.85
6	AGC331061	6002	217	20	1	2.0	0.82
12	PG00000012	6548	400	19	1	2.4	3.40
16	PG00000016	5668	296	20	1	2.2	1.04
38	UGC12893	1108	78	19	1	3.8	2.41
40	PG00000040	7282	289	20	1	5.0	5.20
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